PRELIMINARY OBSERVATION ON THE EFFECT OF WATER FLOW ON PROTOZOAN POPULATION

By

Apollo Hezekiah Ogambo-Ongoma

(*Department of Biology, West Virginia University, Morgantown, West Virginia, U.S.A.*)

INTRODUCTION

Provasoli (1958) has said, "The ecological arena is populated by the products of the continuous challenge of nature to the potentialities of the organisms." Protozoa are in close contact with their environment and should have a rapid and sensitive response to changes. Since one of the most striking variables in a lotic environment is the rate of flow, it was decided to see what effect two markedly differing rates had on the species composition of the protozona "community".

METHODS AND PROCEDURES

This experiment was done at the University of Michigan Biological Station, Pellston, Michigan. The lake water used was from Douglas Lake—the lake on whose shores the station is located.

Two troughs, 24″×2″×3″, made of galvanized iron were set up. They were arranged so that each was tilting at an angle of approximately 15°, so that water could flow through them. However, both ends of each trough were sealed so that water had to flow in, form a pool, and then overflow. Because of the tilting of the troughs, the pool was deep at the bottom ends and became progressively shallower as one approached the elevated ends. The whole experimental set-up was done in a building and hence irridescent light tubes were set up to provide the necessary radiant energy for photosynthesis. Four stones were collected from Douglas Lake beach, these were washed to get rid of organic matter that might harbour protozoans and two of the stones were put in each trough. The stones were to trap organic matter and hence get the Protozoan community to establish.

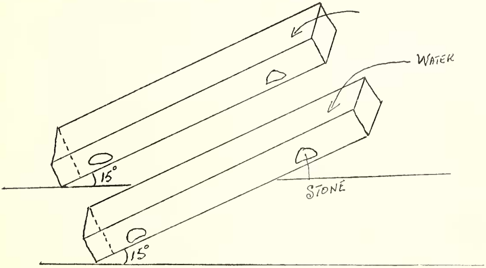


Figure I. Diagram to show trough arrangement.

TABLE I

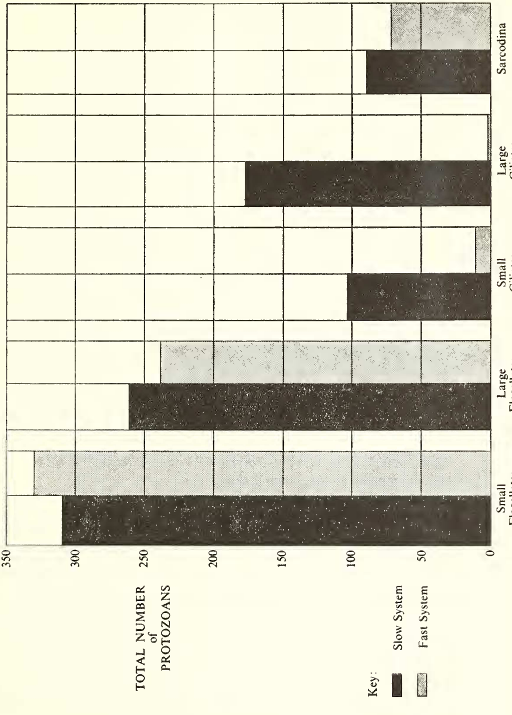
Slow System

Sample	Small flagellates	Large flagellates	Small ciliates	Large ciliates	Sarcodina
2 Days Elevated Area	3	Nil	1	Nil	Nil
Lower Area	4	1	2	Nil	1
6 Days Elevated Area	2	1	Nil	Nil	2
Lower Area	6	3	3	Nil	5
10 Days Elevated Area	26	23	1	1	3
Lower Area	30	7	4	4	7
13 Days Elevated Area	15	9	Nil	Nil	11
Lower Area	50	40	4	2	5
17 Days Elevated Area	23	5	2	10	16
Lower Area	66	57	9	7	5
20 Days Elevated Area	50	100	70	150	30
Lower Area	31	10	5	6	10
Total	306	256	101	180	95

Fast System

Sample	Small flagellates	Large flagellates	Small ciliates	Large ciliates	Sarcodina
2 Days Elevated Area	Nil	Nil	Nil	Nil	Nil
Lower Area	9	1	Nil	Nil	3
6 Days Elevated Area	Nil	Nil	Nil	Nil	Nil
Lower Area	11	7	1	Nil	5
10 Days Elevated Area	1	2	Nil	Nil	Nil
Lower Area	50	9	4	Nil	2
13 Days Elevated Area	2	3	Nil	Nil	Nil
Lower Area	70	52	3	1	11
17 Days Elevated Area	10	Nil	Nil	Nil	Nil
Lower Area	101	60	Nil	Nil	35
20 Days Elevated Area	4	2	Nil	Nil	Nil
Lower Area	70	102	1	Nil	15
Total	328	238	9	1	71

FIGURE 2


TOTAL NUMBER
of
PROTOZOANS
350
300
250
200
150
100
50
0
Small Flagellates
Large Flagellates
Small Ciliates
Large Ciliates
Sarcodina
Key:
Slow System
Fast System

Lake water was then pumped into the two troughs at two different rates.

1. In trough Number I referred to as the Slow System, water was run through at the rate of 4 ml. per second.
2. In trough Number II referred to as the Fast System, water was run through at the rate of 20 ml. per second.

The experiment was set up on July 18, 1966, and the first sampling done two days later; this was then carried out every Wednesday and Saturday of each week for three consecutive weeks. One drop of water containing organic matter constituted a sample and two samples were taken from each trough at each sampling. One of the two samples was taken from the pooled water in the area immediately around the stone in the elevated part of the trough. The second sample was taken from the pooled water in the lower area of the trough. Each time the samples were taken from the floor of each trough, and therefore contained as much of the organic sediments available as possible.

From these samples counts were made and five categories of protozoans were formulated as a basis for grouping and counting.

1. Small flagellate, e.g. members of the Orders Phytomonadina, Chrysomonadina, Protomonadina, and other "small-sized" flagellates.
2. Large flagellates, e.g. larger members of the orders Euglenoidina, Dinoflagellata, and other "large-sized" flagellates.
3. Small ciliates, e.g. members of the order Oligotricha.
4. Large ciliates, e.g. members of the orders Hymenostomata, Spirotricha, Holotricha and other "large-sized" ciliates.
5. Sarcodina.
   In order to give a more critical analysis of the results, it was necessary to divide the ciliates and flagellates into "small" and "large", since they occurred more often. This was not necessary for the Sarcodina and hence they were left as one group.

RESULTS AND DISCUSSION

Results are tabulated in Table I and presented graphically in Figure 2.

In course of experimentation, various things were noted:

1. In both systems, members of the Orders Phytomonadina, Protomonadina, and Chrysomonadina were first to establish themselves. Next to establish themselves were the larger flagellates such as members of the Orders Dinoflagellata and Euglenoidina. Next in sequence of population establishment were the Sarcodina, then smaller ciliates (such as members of the order Oligotricha) and lastly the larger ciliates, e.g. members of the Orders Spirotricha, Hymenostomata and Holotricha).
2. In the Slow System the protozoans were distributed from the lower area of the system right through to the elevated area. However, the lower portion of the system had a much higher concentration of protozoans. The Fast System on the other hand, had a very high concentration of protozoans in the lower area, but almost none in the elevated area of the System.
3. In the Slow System, there was a high concentration of ciliates almost evenly distributed throughout the system. On the contrary, the number of ciliates in all parts of the Fast System was almost negligible. See Table I for the actual counts and Figure 2 for graphic representation.

4. There was less organic sediment in the Slow System as compared to the Fast System. Distribution of the sediment was more even and increased gradually from the lower area to the elevated area of the system. On the other hand, in the Fast System organic sediment accumulated heavily in the lower area and almost none in the elevated area.
5. In the Slow System, whenever a dead crustacean or any small dead metazoan was found, there existed a high concentration of ciliates, especially the larger ones like hymenostomes, spirotrichs, and holotrichs. However, in the Fast System this concentration of ciliates never occurred even where dead metazoans were found. This sudden increase in number due to the dead metazoan may be noted in some counts shown in Table 2.

Seeing that there existed a significant variation in number of ciliates in the two systems: slow system—281 ciliates as compared to 10 ciliates in the fast system, yet both systems had everything equal except for variation in water flow, it was thought that water flow had something to do with this variation. It was therefore decided to reverse the rates of water flow and see what effect this would have. The slow system, had its water flow increased from 4 ml/second to 20 ml./second, and the fast system had its water flow decreased from 20 ml./second to 4 ml./second. Two days after this reversal sampling was done. As before, a drop of water containing organic matter constituted a sample and two samples taken from each system, in same areas as in the original set up. The second sampling was done 4 days, and the third and last one 7 days after the reversal. The population set up with regard to other groups of protozoans remained the same as before in the two systems, and hence no records of their counts were made. However, the ciliates were carefully counted and records made. The results of these counts are shown in Table II and graphical representation in Figure 3.

TABLE II

*"Slow System" (20 ml./second)	Small ciliates	Large ciliates	Total
1st Sample (2 days later) .	3	6	9
2nd Sample (4 days later) .	2	2	4
3rd Sample (7 days later) .	0	0	0
Total	5	8	13
*"Fast System" (4 ml./second)			
1st Sample (2 days later) .	0	0	0
2nd Sample (4 days later) .	4	2	8
3rd Sample (7 days later) .	13	84	97
Total	17	86	105

*These systems have reversed their water flow, however, to reduce confusion of nomenclature to the readers, the original titles are maintained even though the flow has changed. They are therefore put in quotation marks.

On reversal of water flow in the two systems it was noted that the ciliate population in the "slow" system declined very considerably while in the "fast" system no ciliates had established themselves after two days. Four days after the reversal, the "slow" system showed further decline while the "fast" system began to show some ciliates established. Seven days after the reversal, there was a high concentration of ciliates in the "fast" system while the "slow" system had been depleted very considerably of the ciliates.

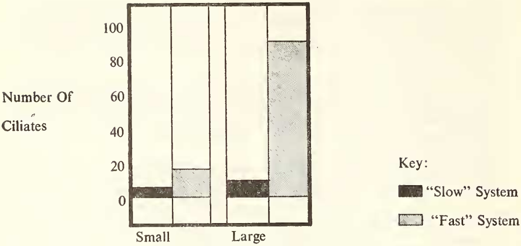


FIGURE 3. Graphic Representation of the New ciliate Population Set up.

It was also noted that where a small dead metazoan occurred, there was exceptionally high concentration of ciliates in the "fast" system while in the "slow" system, this concentration was not evident even where a dead metazoan occurred. This high concentration accounts for the sudden rise in one of the samples.

Results of this experiment were interpreted in the following manner:

1. The sequence in which species become established in the two systems conforms to the generally accepted relationship between "producers" and "consumers". However, exception to this occurred when some organic material (such as a dead metazoan) was introduced in the systems via the lake water.
2. Uniform distribution of organic sediment in the slow system in the original set-up is due to the slow current which allowed sedimentation to occur throughout the system. The fast system of this set up lacked organic sediment in the elevated area due to the swift water current that swept the organic sediments to the lower area before they had a chance to settle.
3. Sudden population increases in all groups in the Slow System on the 20th day is partly due to the presence of a dead metazoan in the system and secondly, in this system sedimentation of organic matter has been increasing gradually from the lower area to the elevated area of the system. Therefore as the organic sediments increases so does the population increase in the area. In this same slow system, the ciliate population tends to remain approximately the same in the lower area, and the increase seems to occur in the elevated area. This is due to the fact that most of the organic sediment was swept to the lower area, and the accumulation in the elevated area seems to be more gradual and hence, the population increases with increase in the amount of organic sediment.

Since all other factors were equal except for the rate of water flow in the two systems, it is apparent that ciliate population distribution was affected by the rate of water flow. This was confirmed when the set-up of the two systems was reversed as shown in Table II and Figure 3.

As to why many ciliates should not exist in a system with a high rate of water flow, it is possible that the reaction of ciliates to gravity has something to do with it.

Ciliates tend to be just below the surface film as a negative response to gravity. (Jennings 1906) established this fact during his work with *Paramecium caudatum*. (Kudo 1966: 157–164.) Since the ciliates remain just below the surface film, they were swept out of the system by the high water current before they had a chance to accumulate and reproduce and therefore establish themselves as part of the protozoan community.

It is therefore evident that under laboratory conditions, water flow affects protozoan population composition and that a high rate of flow more or less eliminates ciliates from the system. Even though this occurred under laboratory conditions, I have no reason not to believe that a similar phenomenon could occur in a stream or any other natural lotic environment.

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